GROWTH VARIATION IN PROGENIES OF 50 'PLUS' TREES OF *ACACIA NILOTICA* (L.) WILLD EX. DEL. SSP. *INDICA* (BENTH.) BRENAN OF CENTRAL INDIA

S. ARYA AND O.P. TOKY

Department of Forestry,
Haryana Agricultural University, Hisar (Haryana).

Introduction

The potential of *Acacia nilotica* (L.) Del ssp. *indica* (Benth.) Brenan (locally known as 'babul') as a multipurpose tree has been recognized worldwide (National Academy of Sciences 1980). This species is found in tropical and sub-tropical Africa and Asia, and throughout dry and hot regions of India ranging from 9°N to 34°N latitude and 72°E to 92°E longitude, and ascending to an altitude of 900 m. It withstands an absolute maximum temperature of 50°C, minimum temperature of –5°C and can be supported by an annual rainfall of 75 to 1,300 mm.

Acacia nilotica ssp. *indica* is a small sized nitrogen fixing tree and forms an important source of timber, fuelwood, fodder, tannin and gum on farmlands in rural India. It has a strong vertical and horizontal root system (Toky and Bisht, 1992), and a long shoot extension period of more than 300 days with four peaks of leaf flush (Bisht and Toky, 1993). Due to these ecological characteristics, this tree is exceedingly drought tolerant, survives on difficult soil sites and is preferred for reforestation of wastelands.

A few provenance trials on *Acacia nilotica* ssp. *indica* have been conducted in India and these studies reported significant variation in seed characteristics (Bagchi *et al*., 1990; Bagchi and Dobriyal, 1990a; Krishan and Toky, 1996b), seed germination and seedling vigour (Bagchi and Dobriyal, 1990b; Krishan and Toky, 1996a), growth in field (Krishan and Toky, 1995b), biochemical contents (Bagchi and Singh, 1992; Krishan and Toky, 1995a) among provenances covering almost the entire semi-arid India. However, little work has been done on selection of 'plus' trees of *Acacia nilotica* ssp. *indica* and testing of progenies.

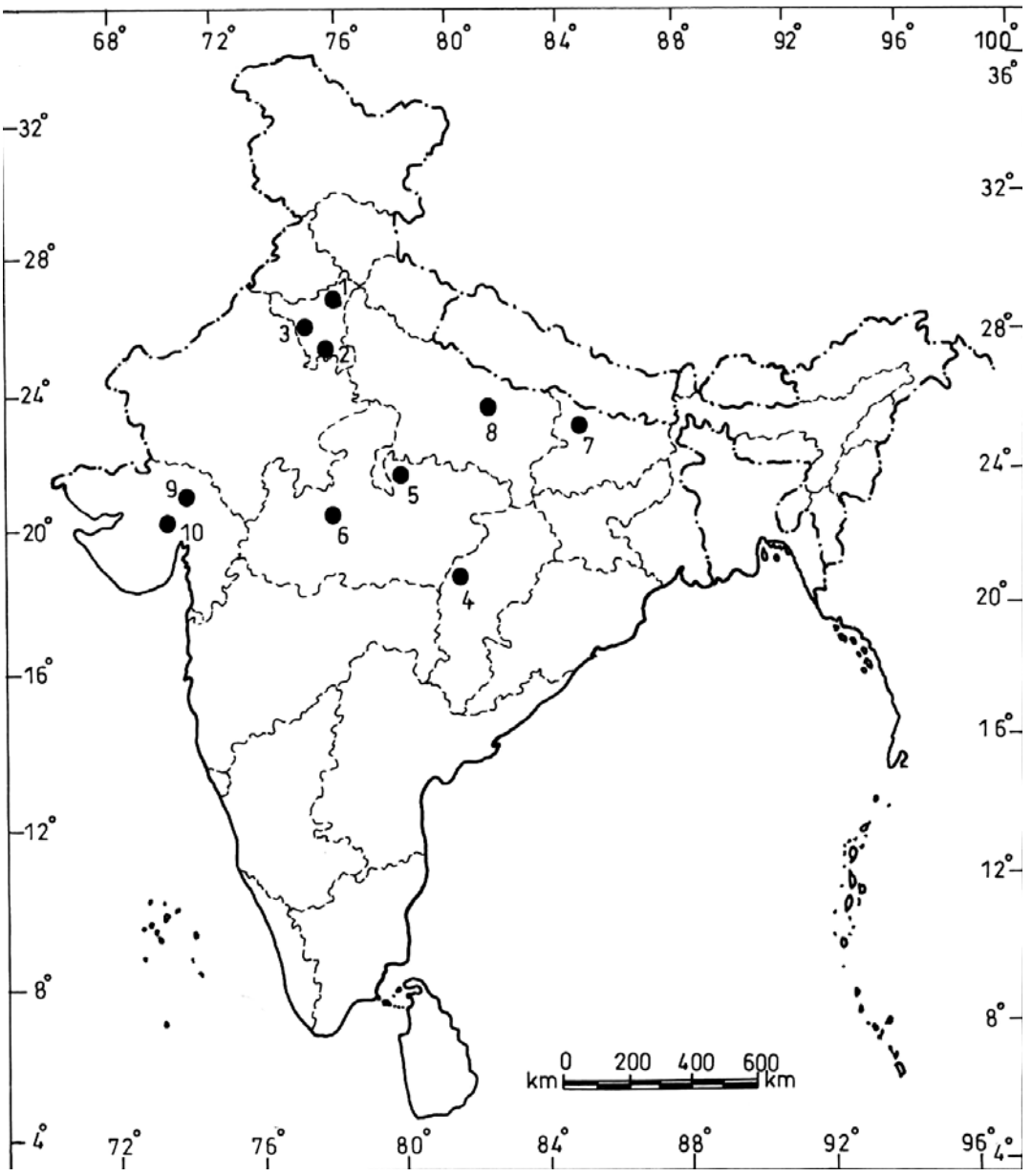
Material and Methods

The seeds of 50 'plus' trees of *Acacia nilotica* ssp. *indica* were collected from five states of Central India (21°14' N to 29° 59' N lat., 72° 38' E to 85° 20' E long., 55 m to 655 m altitude) (Fig.1). The criteria for selection of trees were :

(i) straight tree bole,
(ii) superiority in height,
(iii) conical shape of the canopy, and
(iv) free from diseases.

Ripe pods were sun-dried and seeds were separated through manual threshing to ensure the collection of undamaged seeds. They were further cleaned through winnowing (Doran *et al.,* 1983) and

Fig. 1



Seed collection sites of *Acacia nilotica* ssp. *indica*
1-Kurukshetra (HR 1 to HR 4) ; 2-Rewari (HR 5 & HR 6); 3- Hisar (HR 7 to HR 10); 4-Raipur (MP 1 to MP 5); 5-Jhansi (MP 6 to MP 9); 6-Bhopal (MP 10); 7-Bihar (BH 1 to BH 10); 8- Uttar Pradesh (UP 1 to UP 10); 9 - Mehsana (GJ 1 to GJ 5) and 10- Gandhinagar (GJ 6 to GJ 10).
HR, Haryana; MP, Madhya Pradesh; BH, Bihar; UP, Uttar Pradesh; GJ, Gujarat

fumigated with alminium phosphide. The seeds were stored at room temperature in air-tight aluminium cans.

For seed weight, 3 replication, each of 100 seeds were weighed. Studies on seed germination in polybags and growth in nursery beds and in field were carried out at the campus of Haryana Agricultural University, Hisar located in North-western India (29°10N' lat., 75° 46'E long., 215 m alt.). Seeds were surface sterilized with 0.1% $HgCl_2$ and rinsed with distilled water. After one month, the germination percentage of seeds sown in polybags, was observed.

The seeds of 50 'plus' trees were sown directly in the nursery beds and after 18 months, height, collar diameter and dry weight of plants were recorded. In the nursery, there were 5000 seedlings arranged in RBD design, each mother tree was represented by 100 seedlings. Simultaneously, 3-month old seedlings were transplanted in the field where each mother tree was having 12 seedlings distributed into 3 blocks; total seedlings thus, were 600 of 50 'plus' trees.

Results

There was significant ($P<0.05$) variation for seed weight of 10 mother trees of each state and also between states (Table 1). The seed weight varied from 12.1 g/100 seeds of HR-10 to 21.5 g/100 seeds of BH-9. The mean seed weight was maximum of the Gujarat progenies i.e. 18.6 g/100 seeds closely followed by progenies of Bihar i.e. 18.5 g/100 seeds, and the minimum (15.9 g/100) was that of Madhya Pradesh seed sources. The general coefficient of variation (cv) was 10.4 per cent.

It was interesting to note that weight of the seed was significantly and positively correlated with longitude ($r = 0.525$, $p<0.01$), altitude ($r = 0.431$, $p<0.01$) and rainfall ($r =0.497$, $p<0.01$). The correlation with latitude was however, insignificant.

Seed germination carried out in polythene bags showed wide variation among progenies of each state and also between the states. Germination percentage after one month ranged from 27 per cent of HR-5 to 86 per cent of UP-8 (Table 1). The maximum mean germination percentage was observed of the Uttar Pradesh progenies and minimum of the Gujarat progenies.

Similarly, height of one month old seedlings in polythene bags showed wide variation, and in general, maximum growth was recorded of Uttar Pradesh progenies (16.3 cm) and minimum (12.3 cm) was that of the Gujarat progenies (Table 1). In general, the seedling height ranged from 7.9 cm of GJ-9 to 18.4 cm of UP-2.

The growth of 18 months old plants in the nursery after direct seed sowing varied significantly ($P<0.05$) among 10 mother plants of each state and also between states (Fig. 2). The height of the plants ranged from 1.4 m of GJ-4 to 3.1 m of BH-4, the collar diameter from 11 mm of GH-4 to 19 mm of HR-7 and the dry weight of plant from 465 g/plant of GJ-4 to 1009 g/plant of BH-4. The maximum growth was attained by the progenies of Bihar followed by those of Uttar Pradesh and minimum were that of Madhya Pradesh, and statistically the differences were significant ($P<0.05$). Two seed sources of Haryana i.e. HR-5 and HR-6 showed exceptionally superior growth in all its 10 progenies.

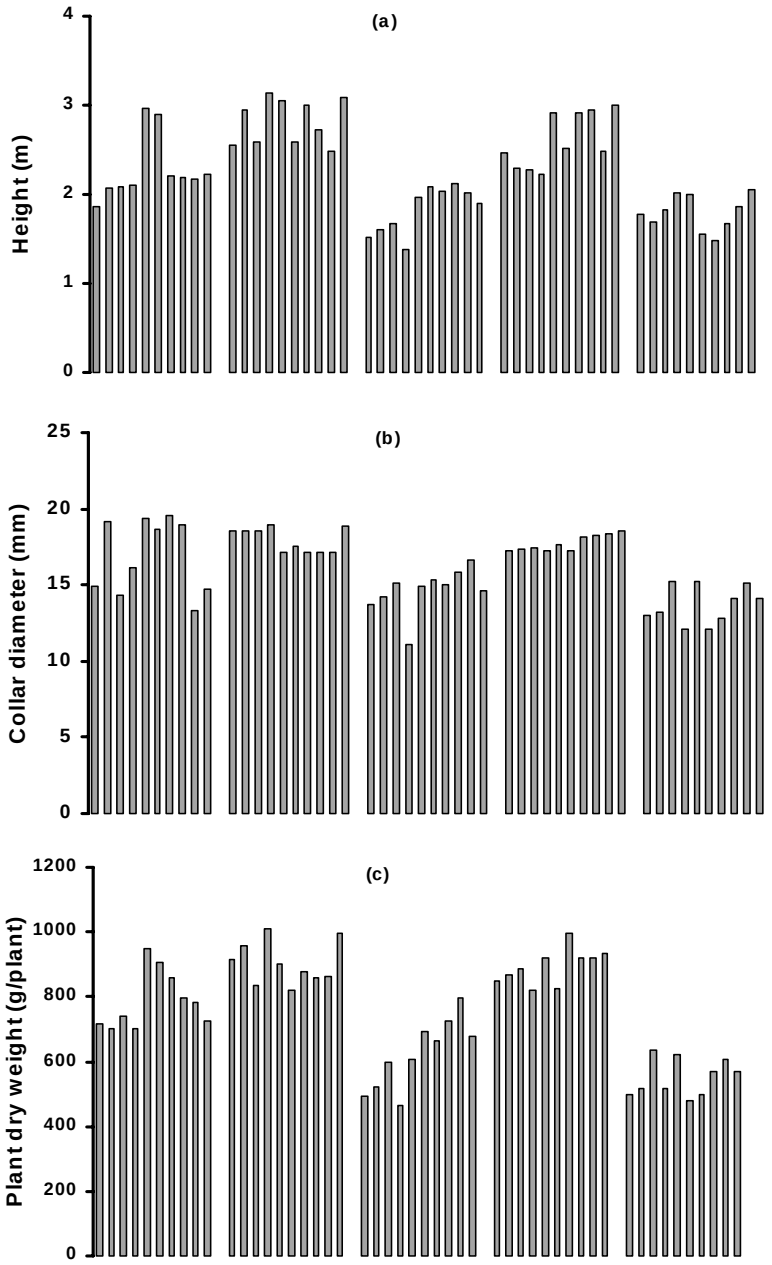
Table 1

Seed weight of 50 'plus' trees of Acacia nilotica ssp. indica collected from five states of India, and seed germination and seedling height of their progenies tested at Hisar, North-western India

Plus tree no.	Haryana (HR)			Madhya Pradesh (MP)			Bihar (BH)			Uttar Pradesh (UP)			Gujarat (GJ)		
	SW	SG	SH	SW	SG	SH	SW	SG	SH	SW	SG	SH	SW	SG	SH
1	16.5	56	16.0	19.4	47	13.9	16.5	60	13.8	17.6	77	15.9	18.8	39	15.7
2	17.9	48	15.6	15.1	64	14.5	19.4	56	15.4	17.9	79	18.4	16.9	35	14.0
3	18.8	58	14.8	15.8	75	11.7	16.0	67	15.9	17.0	76	14.8	18.6	32	13.9
4	17.7	63	16.1	14.8	64	12.7	20.5	64	14.5	17.7	72	17.5	18.7	37	12.6
5	16.3	27	16.5	17.6	71	14.7	17.2	83	15.4	17.3	80	13.0	18.3	34	8.6
6	16.9	40	16.5	16.7	76	14.1	18.6	68	15.6	16.7	64	16.8	19.7	31	8.6
7	15.3	45	16.4	16.1	63	12.2	18.3	77	13.8	17.1	72	17.4	18.0	32	13.6
8	17.0	60	14.6	14.5	43	13.3	16.9	72	15.2	19.9	86	16.9	18.7	33	8.0
9	17.1	47	10.5	13.7	37	14.8	21.5	64	15.6	19.0	83	15.9	19.9	37	7.9
10	12.1	57	14.8	15.4	48	11.9	19.9	60	16.9	18.0	59	16.4	17.7	31	9.8
Mean	16.6	50	15.2	15.9	58	13.4	18.5	67	15.3	17.8	74	16.3	18.5	33	12.3
$CD_{(0.05)}$	0.84		1.2	0.72		1.5	0.69		1.1	0.64		1.5	0.57		1.0

SW=Seed weight (g/100 seed); SG=Seed germination (%); SH=Seedling height (cm) up to 1 month

Fig. 2



Progeny variation in
(a) Height, (b) Collar diameter and (c) Dry weight of plants of 50 progenies in nursery after 18 months

The growth of plants of most of the progenies varied significantly (P<0.05) in the field also (Fig. 3). The height of the plants of 18 months old ranged from 1.3 m of GJ-4 to 3.0 m of BH-4, the collar diameter from 11 mm of GJ-4 to 19 mm of HR-7 and the dry weight from 455 g/plant of GJ-4 to 988 g/plant of BH-4. Progenies such as HR-5 and HR-6 which showed exceptionally superior growth in the nursery also showed superiority in the field. In general, the maximum growth was attained by the progenies of Bihar followed by progenies of Uttar Pradesh and the minimum was that of Madhya Pradesh.

The mean of the progenies (10 from each state) was calculated for 18-month old plants growing in the nursery, and it was observed that height, collar diameter and dry weight of plants were maximum of the Bihar progenies i.e. 2.8 m, 17.9 mm and 904 g/plant, respectively and the minimum were of the Madhya Pradesh i.e. 1.8 m, 13.7 mm and 551 g/plant, respectively (Table 2). Similar trends were observed for 18-month old plants growing in the field.

Height, collar diameter and weight of plants in nursery or field did not show any significant correlation with latitude, longitude, altitude or rainfall of the places of the seed origin.

Discussion

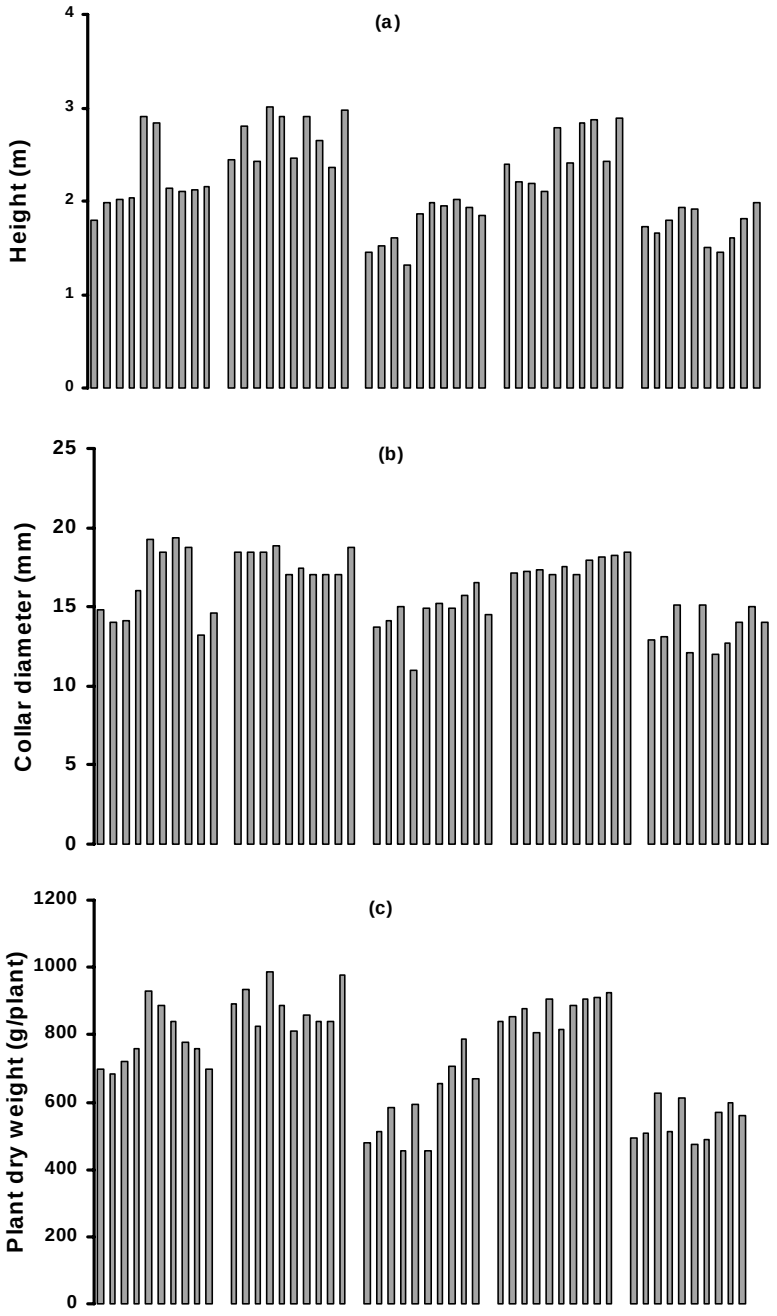
The seed characteristics of 50 progenies of *A. nilotica* ssp. *indica* in the present study showed large variation. Seed weight ranged from 12.1 g to 21.5 g/100 seeds, and in general, the mean seed weight of progenies of Gujarat State were higher closely followed by Bihar and lowest was that of Madhya Pradesh. The variation in seed weight could be due to the embryo genotype and ovary size, which may be the genetic character of different populations. Similar types of data have been recorded by other workers in *Acacia nilotica* (Shivkumar and Banerjee, 1986; Vanangamudi *et al.*, 1998; Bagchi, 1999).

Seed germination percentage also showed large variation; it ranged from 27 to 86 per cent. The overall mean germination percentage was higher of the progenies of Uttar Pradesh State and lower of the Gujarat State. Percentage of seed germination might be affected by the hardness of seeds due to their seed coat. The variation in seed coat hardness/ sensitivity of different provenances resulted in differential germination. The variation in the hardness of seed is possibly due to different environmental conditions of their place of origin. Bagchi (1992) and Ginwal *et al.* (1995) also reported similar results for *Acacia nilotica* ssp. *indica*.

The growth of plants of 50 progenies after 18 months in the nursery and field showed significant differences (P<0.05). The progenies of Bihar showed higher plant height, collar diameter and dry weight and minimum growth was that of the progenies of Madhya Pradesh State. Although, we could not get published information on growth of progenies of plus trees from different states, yet there are some literature available on provenance variation in *Acacia nilotica* (Mathur *et al.*, 1984; Bagchi and Dobriyal, 1992; Bagchi, 1999; Rawat and Singh, 2000).

There are only a few studies made on reproductive biology of *Acacia nilotica*, on this basis of which the wide variation found in the present study, could be explained.

Fig. 3



Progeny variation in
(a) Height, (b) Collar diameter and (c) Dry weight of plants of 50 progenies in field after 18 months

Table 2

Mean values of growth of 18-month old plants of 10 progenies of each state in the nursery and field

States	Height (m)		Collar diameter (mm)		Weight (g/plant)	
	Nursery	Field	Nursery	Field	Nursery	Field
Haryana (HR)	2.3	2.2	16.4	16.3	787	771
Madhya Pradesh (MP)	1.8	1.7	13.7	13.6	551	542
Bihar (BH)	2.8	2.7	17.9	17.7	904	885
Uttar Pradesh (UP)	2.6	2.5	17.7	17.6	894	873
Gujarat (GJ)	1.8	1.7	14.6	14.5	624	612

Nevertheless, Tybirk (1989) described the floral structure of *Acacia nilotica* in Kenya. According to this study, there are two types of flowers i.e. unisexual and hermaphrodite in *Acacia nilotica*, and out of which 1/3rd are hermaphrodite of which about 30% set seeds indicating cross pollination behavior of the species.

Further, there are reports that hybridization is frequent in *Acacia nilotica* complex (Ali and Qaiser, 1980). The hybrid population may backcross with *Acacia nilotica* ssp. *indica* and *A. nilotica* ssp. *hemispherica* producing plants similar to *A. nilotica* ssp. *adstringens* and *A. nilotica* ssp. *subulata,* respectively. There are well proved hybrids of *Acacia nilotica* ssp. *indica* and *A. nilotica* ssp. *cupressiformis*.

It is interesting to note that the period of flowering in *A. nilotica* ssp. *indica* is quite long in North-western India. Flowering starts in July and continues until mid-November. During summer (July to October) however, there is no fertilization due to high temperature. Successful fertilization occurs in mid-November, and interestingly, the fertilized ovules remain dormant during winter (December to February) and the growth of the fertilized ovule occurs subsequently during spring season and pods mature during May and June (K.S.Bangarwa, personal communication). In southern and middle parts of India, the seeds mature one month earlier as compared to North-western India. The variation found in the growth of different progenies in the present study, could also be attributed to floral biology and different maturation period for pods because *Acacia nilotica* ssp. *indica* has a wide range of distribution and occurs over large range of agro-climatic conditions in India.

Acacia nilotica ssp. *indica* occurs on wide varieties of soil types including saline soils. An important study revealed that provenances of *Acacia nilotica* ssp. *indica* exhibit differential response in growth in saline soils ranging from 4 to 12 ECe (Bimlendra *et al.*, 2002), which is perhaps due to physiological adaptation, and hence, explains the variation within populations.

The variability in *A. nilotica* ssp. *indica* is of great significance in breeding work. The growth characteristics in the

nursery explain the variation and vigour of the species which are ultimately correlated with survival and production (Burley and Wood, 1976). Thus, the study may be helpful in selection of better genotypes which may be useful in establishment of seed orchards of this important multipurpose species.

Fifty progenies discussed in the present study were also studied for nitrogen fixing ability in another experiment by us. Bihar progenies showed higher nitrogen fixing ability closely followed by Uttar Pradesh progenies and lower were that of Madhya Pradesh progenies. The means of progenies of each state also varied significantly having the highest value for Bihar provenance and the lowest for Madhya Pradesh provenance. Significant positive ($P<0.01$) correlation was observed in between the number of nodules, dry weight of nodules, plant dry weight and nitrogen concentration (Arya, 2002). Our earlier work also reported wide variation in nitrogen fixing abilities among progenies of this species (Beniwal *et al*., 1994; Toky *et al*., 1995).

The 30 progenies of three states (Haryana, Uttar Pradesh, Gujarat) were also subjected to esterase and peroxidase isoenzyme analysis. The similarity value ranged from 0.214 to 1. In general, less genetic diversity was observed in Gujarat provenance, medium in Uttar Pradesh and wider in that of Haryana, and there were similarities between some progenies of 3 states. The phenetic tree or dendrogram revealed the co-efficient level of 0.53 and three clusters i.e. A, B and C with 6, 8 and 10 progenies, respectively (Arya and Toky, unpublished).

Conclusion

Wide variability in growth of progenies of 50 plus trees collected from 5 states was observed. After 18-month growth, the progenies of Bihar and Uttar Pradesh showed significantly higher height, collar diameter and dry weight of plants while minimum growth was observed in the progenies of Madhya Pradesh State. This is a long-term study, and the superiority of the seed sources would be known after at least 10 years of the growth in the field. The wide variability in *A. nilotica* ssp. *indica* is of great significance in breeding work. The study would be useful in selection of better genotypes, and further establishment of seed orchard.

Acknowledgements

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SUMMARY

Acacia nilotica ssp. _indica_, an important agroforestry tree occurs extensively on farmlands throughout semi-arid India. The seeds of 50 'plus' trees were collected from 5 states of Central India (21°14' N to 29°59' N lat., 72°38' E to 85°20' E long., 55 m to 655 m alt.), and studies on seed germination in polybags and growth in nursery beds and in field were carried out at the campus of Haryana Agricultural University, Hisar located in North-western India (29°10 N' lat., 75°46' E long., 215 m alt.). The seed weight of 50 plus trees ranged from 12.1 g to 21.5 g/100

seeds and seed germination from 27 to 86 per cent. Weight of the seed was significantly and positively correlated with longitude (r = 0.525, p<0.01), altitude (r = 0.431, p<0.01) and rainfall (r =0.497, p<0.01). The correlation with latitude was however, insignificant. The growth of 18 months old plants in the nursery varied significantly (P<0.05) among 10 mother plants of each state and also between states. The height of the plants ranged from 1.4 m of GJ-4 to 3.1 m of BH-4, the collar diameter from 11 mm of GH-4 to 19 mm of HR-7 and the dry weight of plant from 465 g/plant of GJ-4 to 1009 g/plant of BH-4. Two seed sources of Haryana i.e. HR-5 and HR-6 showed exceptionally superior growth in all its 10 progenies. Similar trends were observed for plants growth in the field. The wide variability in *A. nilotica* ssp. *indica* is of great significance in selection of better genotypes, and further establishment of seed orchard.

मध्यवर्ती भारत में *अकेसिया नीलेटिका* (लि०) विल्डे० निषेध डेल० उपजाति *इण्डिका* (बेन्थ०) ब्रेनन के 50 श्रेष्ठ वृक्षों की सन्ततियों में वृद्धि विभिन्नता

एस० आर्य व ओ०पी० टोकी

सारांष

अकेसिया नीलोटिका उपजाति इण्डिका अर्द्धशुष्क भारत में सर्वत्र खेतों पर विस्तार से लगाई जाने वाली महत्वपूर्ण कृषिवानिकी वृक्षजाति है। इसके 50 श्रेष्ठ वृक्षों के बीज मध्यवर्ती भारत के पांच राज्यों ($21^o14'$ उत्तर से 29^o 59' उत्तर अक्षांश, 72^o 38' पूर्व से 85^o 20' पूर्व देशान्तर, 55 मी० से 655 मी० ऊंचाई) से एकत्रित किए गए और उन्हें हरियाणा कृषि विश्वविद्यालय, हिसार, उत्तर पश्चिमी भारत में स्थित (29^o 10' उत्तर अक्षांश 75^o 46' पूर्व देशान्तर, 215 मी0 ऊंचाई) परिसर में पोलिथीन थैलियो रोपणी और क्षेत्र में रोपकर उनके बीजांकुर का अध्ययन किया गया। इन 50 श्रेष्ठ वृक्षों का बीज भार 12.1 ग्राम से 21.5 ग्राम/100 बीज तक था और बीजाकुंरण 27 से 86% तक रहा। बीजों का भार देशान्तर ($r = 0.525, p < 0.01$), ऊंचाई ($r = 0.431, p < 0.01$) और वर्षा ($r = 0.497, p < 0.01$) के साथ सार्थकतः और धनात्मक सहसबंधित पाया गया। किन्तु अक्षांश से उसका सहसम्बन्ध नगण्य पाया गया। रोपणी में लगाए 18 मास के पौधों की बढ़वार में प्रत्येक राज्य के 10 मातृ पादपों और राज्यों में भी काफी अन्तर ($p < 0.05$) रहता पाया गया। पौधों की ऊंचाई GJ - 4 की 1.4 मी० से लगाकर, BH-4 की 3.1 मी० तक, मूलसंधि पर व्यास GH-4 के 11 मिमी से लगाकर HR-7 के 19 मिमी तक, पादप का शुष्क भार GJ-4 के 465 ग्राम/पौधा से लगाकर BH-4 के 1009 ग्राम/पौधा तक रहता पाया गया। हरियाणा के दो बीज स्रोतों अर्थात HR-5 और HR-6 ने अपनी सभी 10 सन्ततियों में असाधारण श्रेष्ठ बढ़वार प्रदर्शित की। ऐसी ही प्रवृति क्षेत्र में लगाए गए पोधों की बढ़वार में देखने को मिली। *अकेसिया नीलोटिका* उपजाति *इण्डिका* में पाई जाने वाली ज्यादा विभिन्नता श्रेष्ठता समपित्रैकों का चुनाव करने और बीज उद्यानों की स्थापना करने की दृष्टि से बहुत महत्व की है।

References

Ali S.I. and M. Qaiser (1980). Hybridisation in *Acacia nilotica* (Mimosoideae) complex. *Bot. J. Linnean Soc.,* **80** : 69-77.

Arya, S. (2002). Comparative performance analysis of 'plus' trees progenies of *Acacia nilotica* (L.) ex Del. ssp. *indica* (Benth.) Brenan. *Ph.D. Thesis*, Forest Research Institute, Dehra Dun, India. pp.117.

Bagchi, S.K. and N.D. Dobriyal (1990a). Provenance variation in seed parameters of *Acacia nilotica*. *Indian Forester*, **116** (12) : 958-961.

Bagchi, S.K. and N.D. Dobriyal 1990b. Seedling character variation and root-type in *Acacia nilotica*. *Ind. J. For.,* **13** : 207-209.

Bagchi, S.K. and J. Singh (1992). Provenance variation in *Acacia nilotica*: Free-proline content in leaves. *Indian Forester,* **120** (6) : 529-532.

Bagchi, S.K. (1992). A preliminary study on the genetic divergence of *Acacia nilotica* through seed parameters. *Indian Forester,* **118** (4) : 416-424.

Bagchi, S.K. (1999). Seed source variation in *Acacia nilotica* genetic divergence in 8-month-old seedlings. *Ann. For*., **7** : 45-55.

Bagchi, S.K., D.N. Joshi and D.S. Rawat (1990). Variation in seed size of *Acacia* species. *Silvae Genetica*, **39** : 107-110.

Beniwal, R.S., O.P. Toky and P.K. Sharma (1994). Genetic variability in symbiotic nitrogen fixation between provenances of *Acacia nilotica* (L.) Willd ex Del. *Genetic Resources and Crop Evolution,* 42 : 7-13.

Bimlendra, K., O.P. Toky and S. Babber (2002). Seed source (provenance) variation in *Acacia nilotica* (L.) Willd for salinity tolerance. *Ann. Arid Environ.* (In press).

Bisht, R.P. and O.P. Toky (1993). Growth pattern and architectural analysis of nine important multipurpose trees in arid region. *Can. J. For. Res.,* **23** : 722-730.

Burley, J. and P.J. Wood (1976). A Manual of species and provenance research with particular reference to tropics. *Trop. For. Pap. No. 10*, CFI, Oxford.

Doan, J.C., J.W. Turnbull, D.J. Boland and B.Vr. Gunn (1983). *Handbook on seeds of dry zone Acacias*. FAO, Rome. pp.92.

Ginwal, H.S., P.S. Rawat, M. Gera, N. Gera and R.L. Srivastava (1995). Study on the pattern of seed germination of various subspecies cum provenances of *Acacia nilotica* Willd ex. Del. under nursery conditions. *Indian Forester* **121** (1) : 29-37.

Krishan, B. and O.P. Toky (1995a). Variation in foliar biochemical and nutrient contents among provenances of *Acacia nilotica* ssp. *indica*. *J. Trop. For. Sci.,* **8** : 78-86.

Krishan, B. and O.P. Toky (1995b). Provenance variation in growth characteristics of *Acacia nilotica* ssp. *indica* in arid India. *Indian Forester,* **121** (4) : 179-186.

Krishan, B. and O.P. Toky (1996a). Provenance variation in seed germination and seedling growth of *Acacia nilotica* ssp. *indica* in India. *Genetic Resources and Crop Evolution*, **43** : 97-101.

Krishan, B. and O.P. Toky (1996b). Provenance variation in seed characteristics of *Acacia nilotica* ssp.*indica* (Benth.) Brenan. *Plant Genetic Resources Newsletter*, **105** : 1-2.

Mathur, R.S., K.K. Sharma and M.M.S. Rawat (1984). Germination behaviour of various provenances of *Acacia nilotica* ssp. *indica*. *Indian Forester*, **110** (5) : 435-449.

NAS (1980). *Firewood Crops: Shrubs and Trees Species for Energy Production*. National Academy of Sciences, Washington, D.C. pp.237.

Rawat, J.S. and T.P. Singh (2000). Seedlings indices of four tree species in nursery and their correlations with field growth in Tamil Nadu, India. *Agroforestry Systems,* **49** : 289-300.

Shivkumar, P. and A.C. Banerjee (1986). Provenance trials of *Acacia nilotica*. *J. Tree Sci*., **5** : 53-56.

Toky, O.P. and R.P. Bisht (1992). Observations on the rooting patterns of some agroforestry trees in an arid region of North-western India. *Agroforestry Systems*, **18** : 245-263.

Toky, O.P., N. Kaushik and P.K. Sharma (1995). Genetic variability in progenies of *Acacia nilotica* (L.) ex. Del. ssp. *indica* (Benth.) Brenan for nitrogen fixing ability. *Silvae Genetica*, **44** : 161-165.

Tybirk, K. (1989). Flowering, pollination and seed production of *Acacia nilotica*. *Nordic J. For*., **9** : 375-381.

Vanangamudi, K., R. Umarani, A. Bharathi and A. Venkatesh (1998). Effect of seed source on physical and physiological qualities of *Acacia nilotica* seeds. *Seed Res*., **26** : 114-116.